OXCART
P+E REPORT

29 August 1961

ACTIVITY SUMMARY

The last report (MB-M-317) recommended that two months be spent examining alternate lens designs with the objective of finding one which was at least adequate to 5^{o} half field angle and, preferably, over the entire 10^{o} field. During this time we have considered three general approaches and five specific designs. These were:

1. New lens of a Petzval form.
2. A proposal by J. G. B.
3. Three minor variants of the existing design.

DISCUSSION

1. A new lens of the Petzval form would probably be entirely adequate from the points of view of static resolution and distortion over a 10^{o} half field, but it would create major problems in thermal control and mechanical redesign (because of the basically different configuration and the thermal jacketing). It was felt that the drawbacks of this approach far outweighed the potential advantages.

2. The design modification proposed by JGB makes use of the fact that four independent variables are always sufficient to correct four conditions in an optical design. It was JGB's proposal that a lens form of the ADH type be considered in which the aspheric on the secondary, the aspheric on the primary, the location of the stop, and an aspheric at the stop be the four variables used to control distortion, third order astigmatism, third order coma, and spherical. JGB pointed out that this is a mathematically sufficient situation, but that it probably would be difficult to fabricate optically.

Our Senior Lens Designer has considered these suggestions and concurs with them. He points out that the aspherics required on the primary and secondary are extremely strong (about a factor of 15 stronger than the aspherics presently employed on the existing secondary), and that it is unlikely that such strong aspherics will result in an appreciable field of view. The strong aspherics are required to remove higher order aberrations which are tremendously important when such high performance is sought. Presumably something could be worked out which would be adequate for a narrower field of view, but this would require two or three months of optical design effort, and might not improve the situation. There is virtually no question that the fabrication of such a system, even if the smaller field of view was acceptable, would be extremely difficult. The aspherics would all require special tests, and our experience a few years ago with the Satellite Tracking Cameras indicated that six to twelve months is probably required to fabricate such test optics, at which time a beginning can be made on the basic optical system.

Assuming that this first objection could somehow be overcome in a reasonable time, which is not a realistic assumption, we would probably be left with a lens design so greatly different from the present lens design that the entire mechanical configuration of our system would have to be redone.

On the basis of these reasons, we felt that no more time should be spent on this particular approach.

3. Minor variants of the existing design were extremely attractive because implementing them would not be difficult, provided they were satisfactory optically. The three particular variants that were considered were:

a. Aspherize a small new element after the deviating prism;
b. Aspherize the existing filter element; and
c. Aspherize one surface of the prism and the existing filter.

The first two of these were more attractive since less optical complexity is involved. The last one of these involves working two surfaces and, at the time a decision had to be made, it was not clear that the greatly increased manufacturing complexity could be justified, since there was no evidence to suggest that the last suggestion would be significantly better than either of the first two. The first two were both examined briefly by the designer with the computer, and the second of the two variants (aspherizing the present filter) was found to be superior. This design was carried through to completion.

RESULT OF NEW DESIGN EFFORT

Figures 1 and 2 compare the new design's transfer function with the old as a function of field angle for two spatial frequencies. At the higher spatial frequency, performance is essentially the same within 5^{o} half-field angle and falls off fairly strongly at about $7\frac{1}{2}^{o}$. Figures 3 thru 6 give this information in another fashion.

From the point of view of operational performance, the new design performance is illustrated in Figures 7 and 8. These reveal that the performance has been "balanced" much better in the two directions by the new design than the old design, when the effect of distortion is included.

In terms of ground coverage, overlap is such that 95.8% of the photographic flight path is still photographed at least twice with the higher quality images within the central 15^{o} (total field) and 99.6% twice within the central $17\frac{1}{2}^{o}$. Every part of the photographic ground coverage is still photographed at least twice.

ALTERNATIVE CHOICES NOW AVAILABLE

There appear to be three possible alternates available now:

1. Continue with the old design;
2. Study other optical designs more fully; or
3. Build the slightly modified design of the present optical system, in which the design modification consists of aspherizing the present filter.

Continuing with the old design has the advantage of representing very little redesign and makes use of existing tooling, but forces us to accept an operational performance level which seems objectionally low. However, this course may be adequate if a new fast film will be available.

Studying additional design (for instance the third minor varient of the existing design) would require another two months time for any one design variant and does not assure improving the situation at all. If time were available this might be considered.

Building the new proposed design requires us to modify the tooling since all of the surfaces are slightly changed, requires us to modify the test setups for the changed elements, and requires the new filter (now called field corrector) to be aspherized. The aspheric on the field corrector forces us to use a dichroic spectral filter instead of the glass previously employed. We believe that the first new optical system can be transferred from the Manufacturing Department, as cut and coated elements, to the Project Plant in six to nine months, allowing for tooling and test modification, assuming work commences 5 September.

RECOMMENDATION

We recommend that the new design be fabricated and considered as a final design for operational units. We feel its performance is entirely consistent with the original program objectives.

MB-M-336
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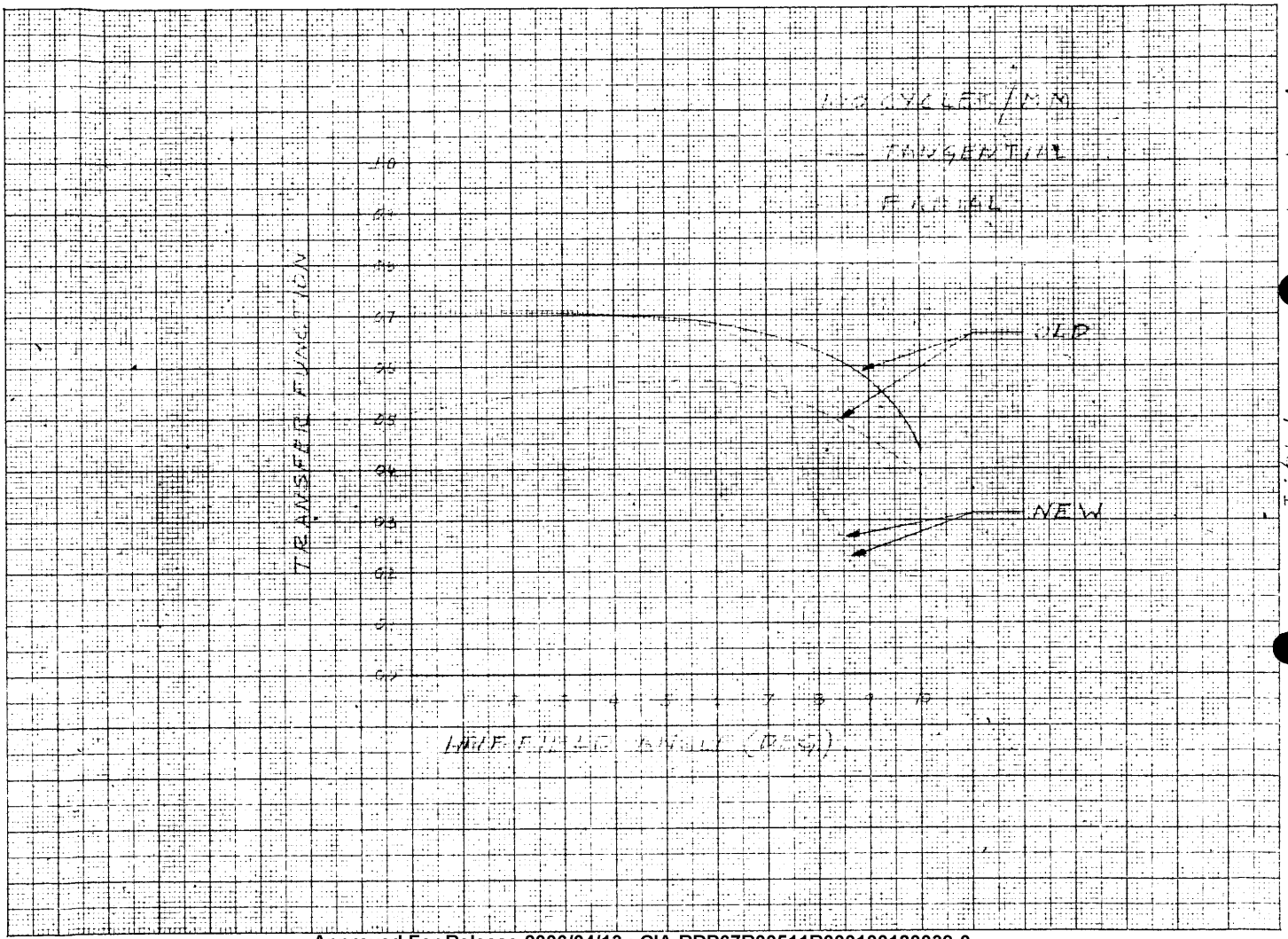


FIG. 1

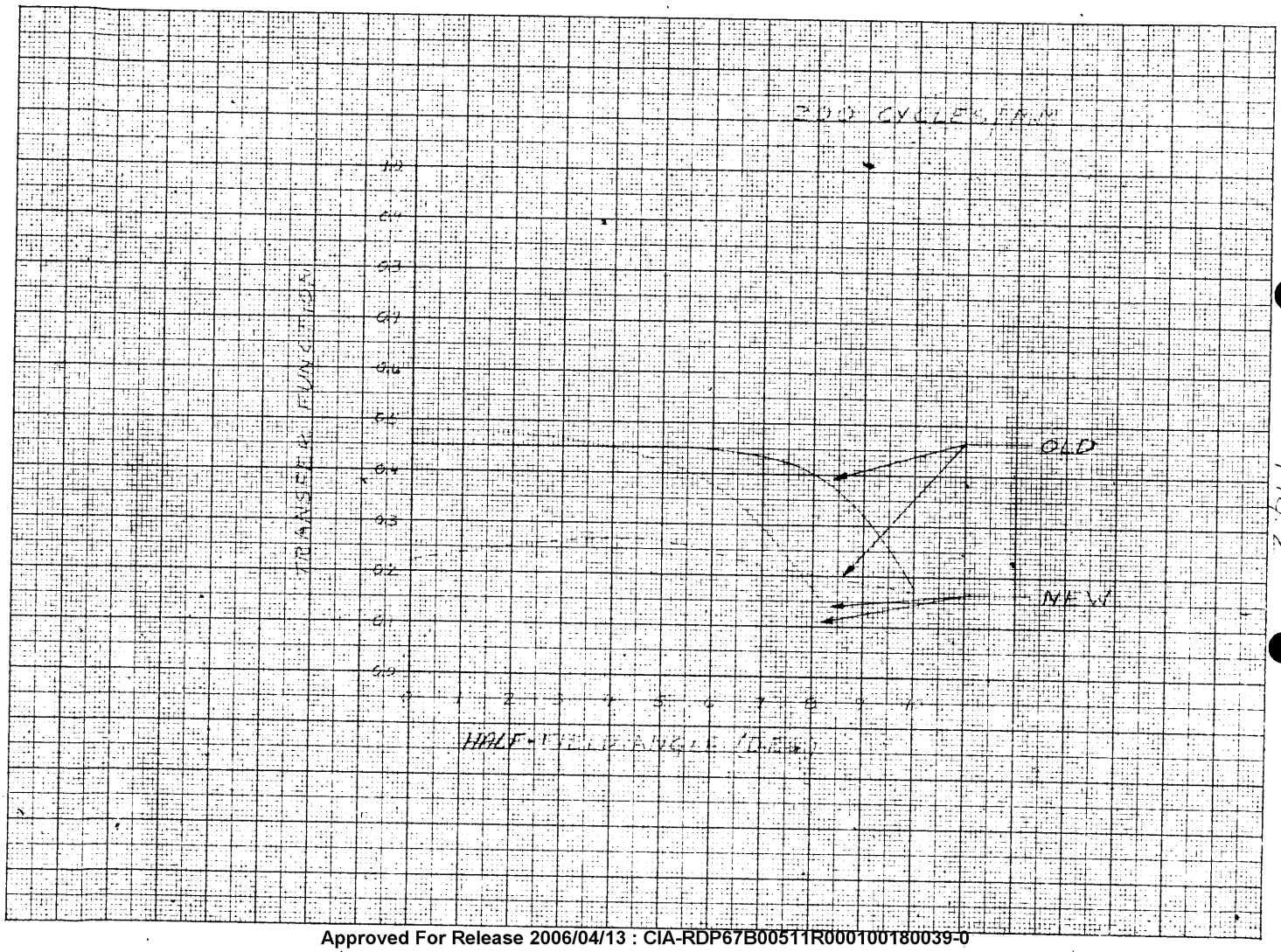


FIG. 2

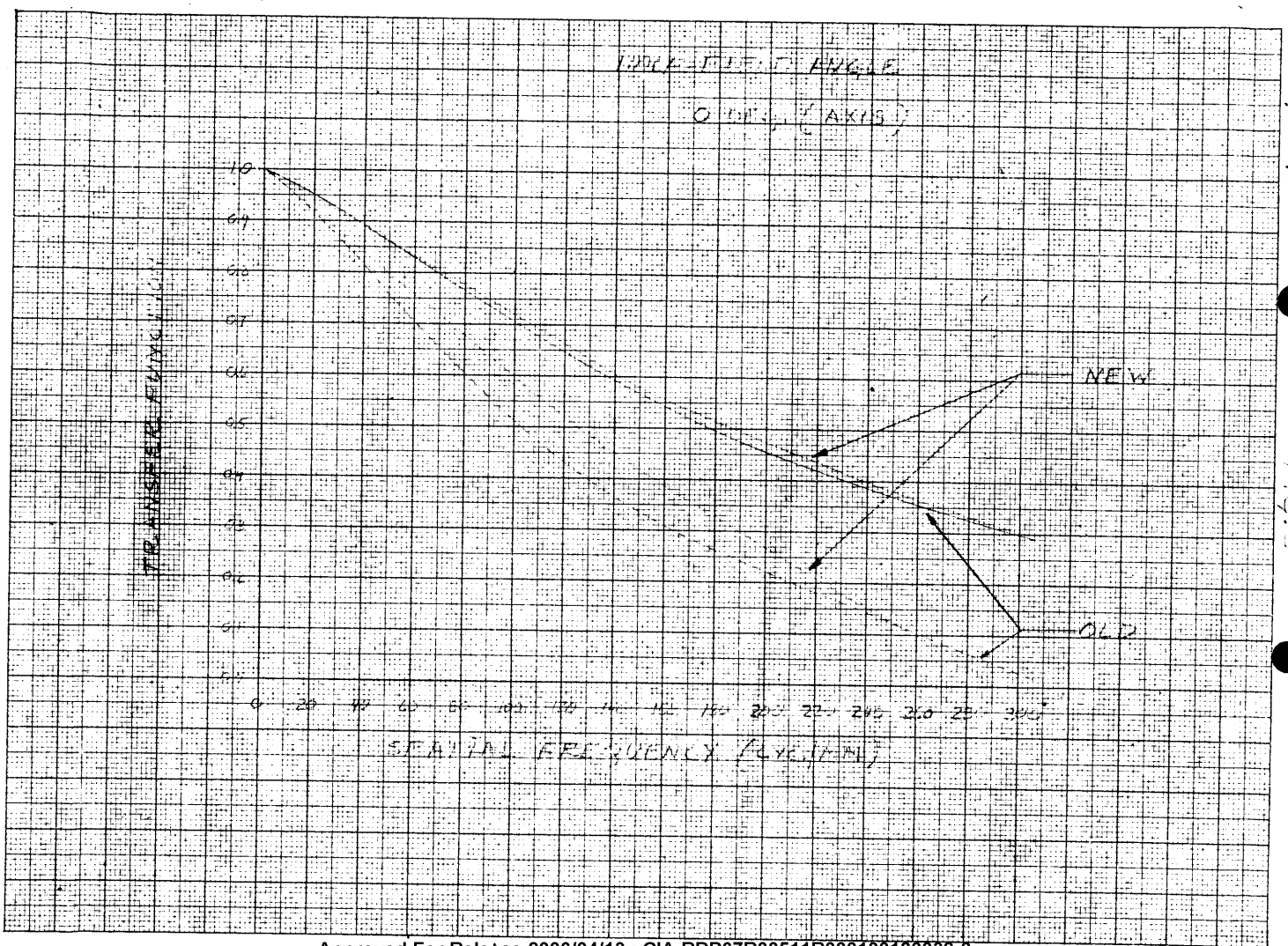


Fig. 15

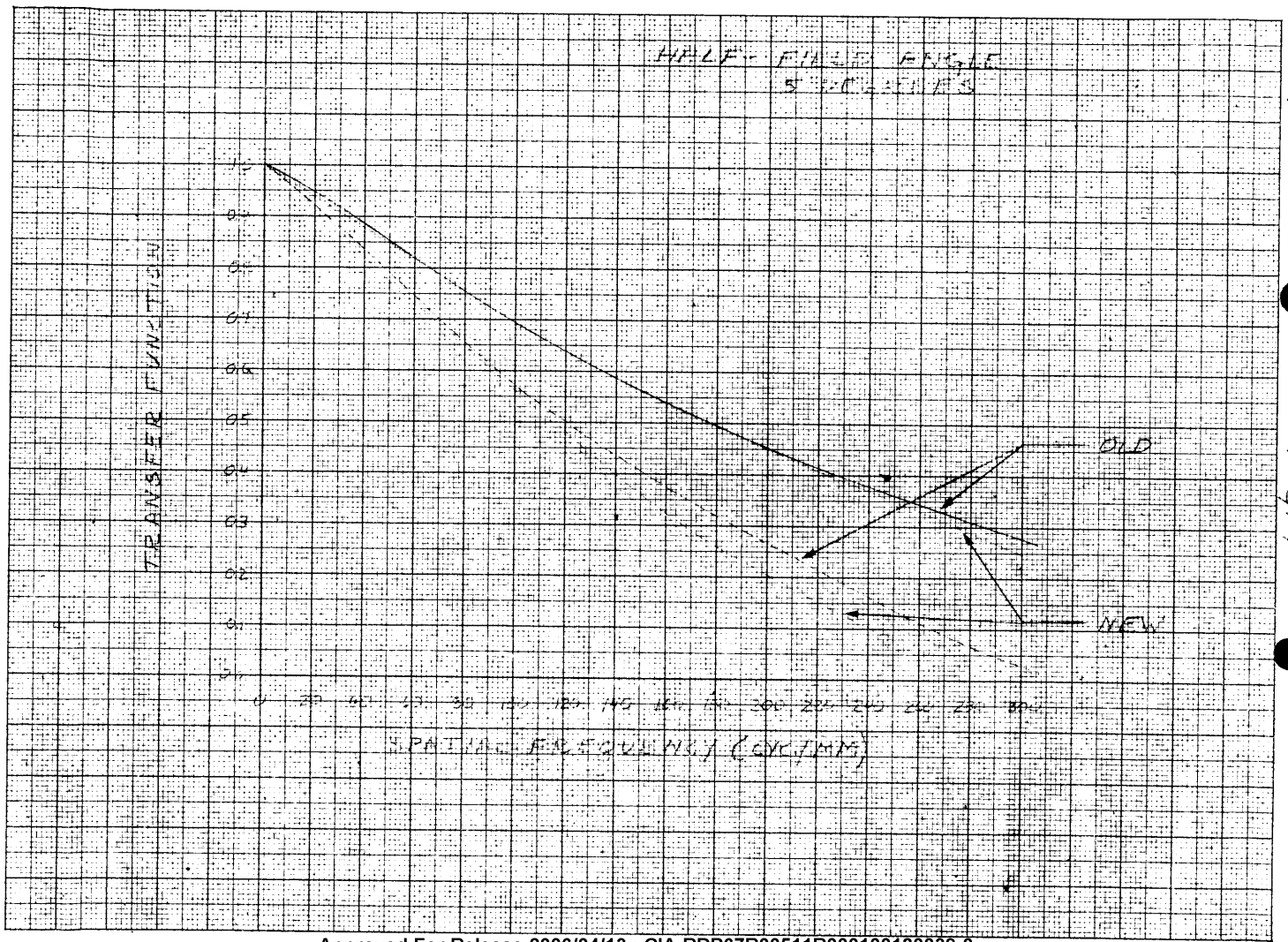


FIG. 4

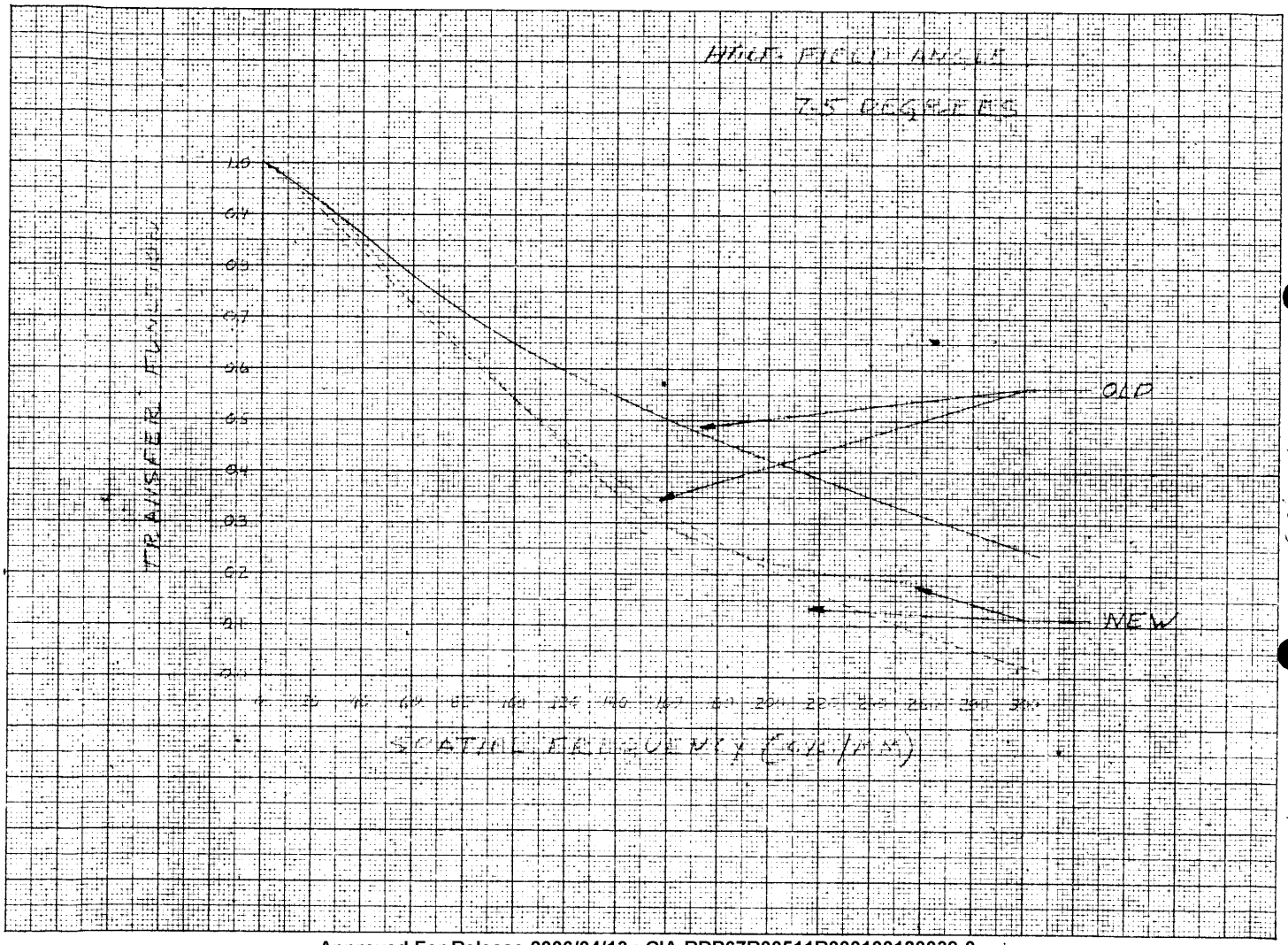
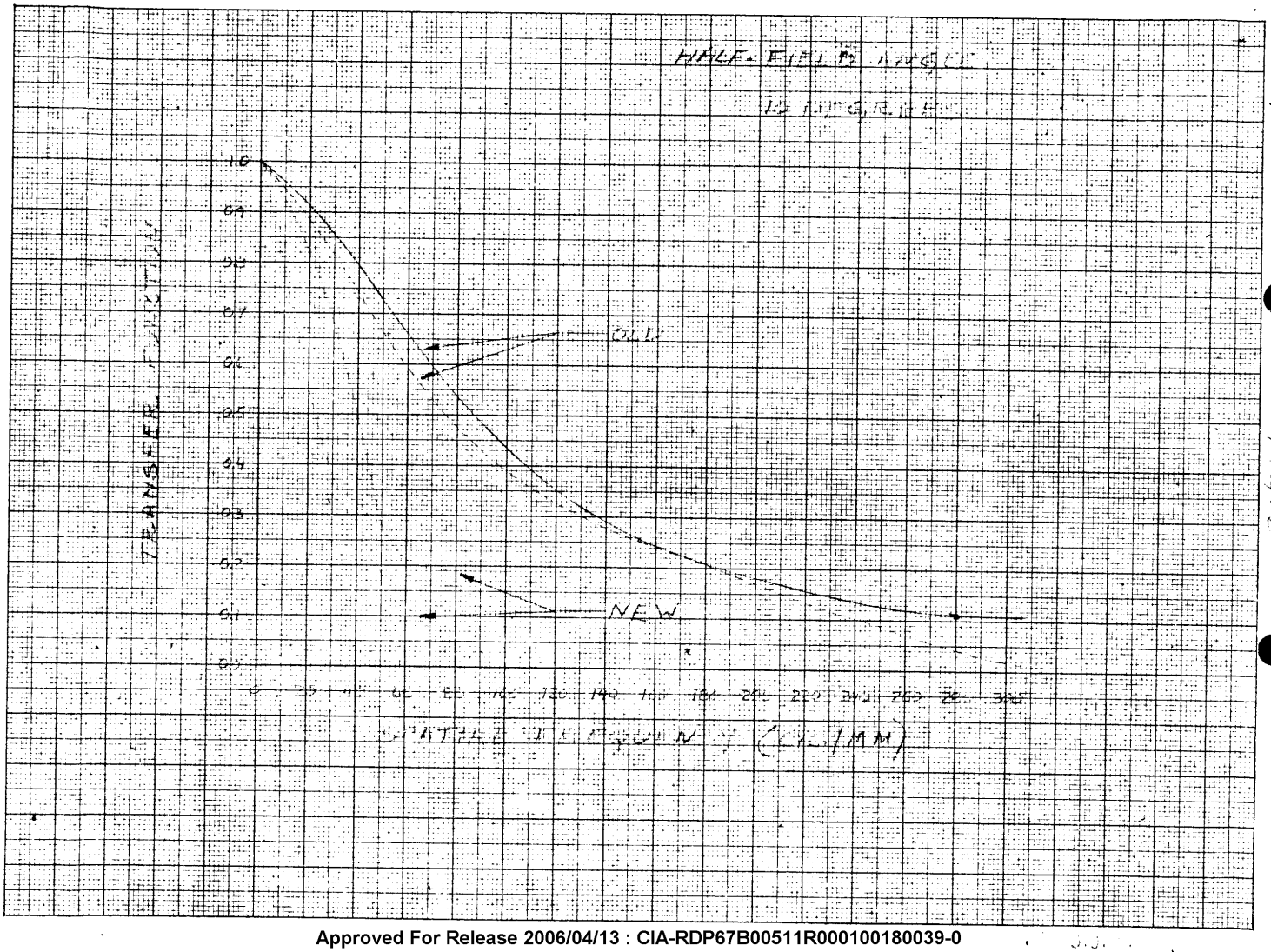
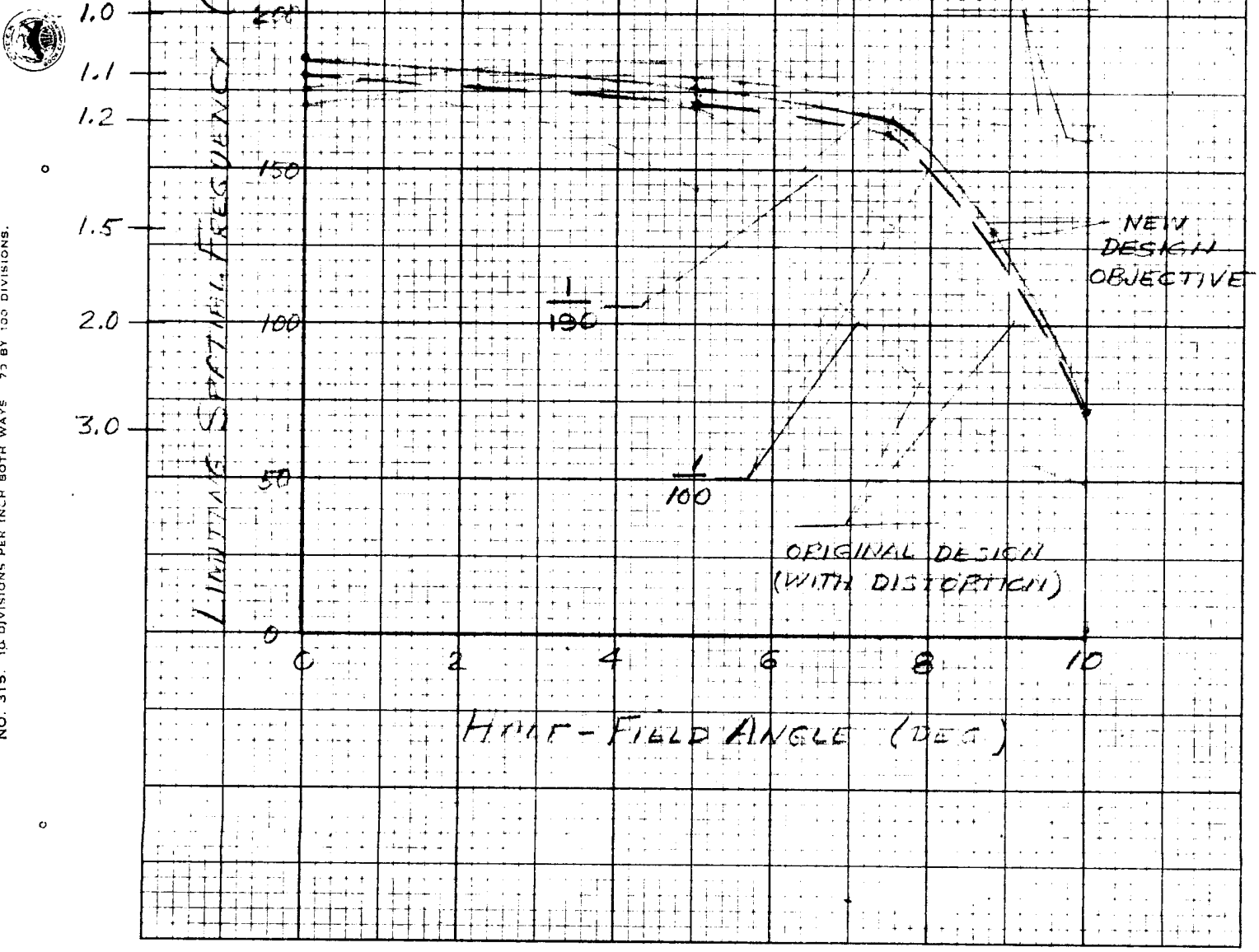


FIG. 5



PREDICTED LIMITING OPERATIONAL PERFORMANCE

(SHORT DIRECTION OF APERTURE)



MDA
15 Dec 61